

Band No.	Age	State	Coord.	Banded	Recovered	State	Corrd.	Method
41121080	I	Calif.	342-1194	01-12-43	05-26-44	B. C.	490-1224	found dead
47119626	A	Calif.	375-1221	02-08-49	06-25-49	Wash.	471-1221	found dead
50076019	I	Calif.	340-1182	12-20-51	05-04-52	B. C.	482-1232	trap & rel.
20177138	A	Calif.	380-1220	04-10-53	07-01-54	Wash.	481-1223	trapped
20148109	—	Calif.	375-1223	10-04-53	04-10-56	Wash.	485-1221	found dead
23147027	I	Calif.	374-1221	02-03-56	04-17-57	Wash.	473-1222	found dead
25118192	—	Calif.	372-1215	11-23-57	04-06-60	Wash.	485-1224	trap & rel.
24180958	I	Wash.	485-1224	09-06-58	02-10-59	Calif.	405-1240	found dead
27169506	I	Wash.	485-1224	09-10-59	10-19-59	Calif.	351-1203	cat
27169514	—	Wash.	485-1224	09-18-59	11-07-59	Calif.	372-1215	trap & rel.
27104107	—	Calif.	372-1215	11-11-59	08-22-60	B. C.	490-1234	found dead
22136419	—	B. C.	491-1230	08-26-59	12-31-61	Calif.	371-1214	trap & rel.
28121415	—	Calif.	365-1215	01-12-60	05-06-61	Wash.	461-1232	cat
28155446	I	Calif.	365-1220	10-08-60	05-25-61	Wash.	483-1223	found dead
29184084	A	Calif.	380-1220	03-04-61	05-25-61	B. C.	490-1230	injured
32175722	I	Calif.	371-1214	12-31-62	04-15-63	Wash.	473-1223	hit object
31188552	A	Calif.	370-1213	03-26-62	05-12-62	Wash.	480-1232	hit object
31138666	A	Calif.	372-1215	01-28-62	08-19-62	Wash.	484-1222	cat

## PLUMAGES, MOLT AND MORPHOMETRY OF TENNESSEE WARBLERS

By DENNIS G. RAVELING\* AND DWAIN W. WARNER

### INTRODUCTION

Thousands of birds have been killed during fall migration at the Eau Claire, Eau Claire County, Wisconsin television tower (Kemper, 1958, 1959, 1964). Dr. C. A. Kemper has generously salvaged and donated thousands of specimens to the Minnesota Museum of Natural History. These large samples of migrants have much potential for study, as well pointed out by Tordoff and Mengel (1956).

Approximately 800 Tennessee Warblers (*Vermivora peregrina*) were killed at the Eau Claire tower in the fall of 1961 and 1962. cursory examination of these Tennessee Warblers indicated that previous plumage descriptions of the age-sex classes contained inaccuracies and were often incomplete. These TV tower killed samples provided an opportunity to learn more of the sex, age, and individual variability in plumage patterns and morphology of the Tennessee Warbler. To understand further plumage changes and variability, approximately 1200 Tennessee Warbler museum specimens collected throughout the entire year were examined.

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PLUMAGE CHARACTERS OF THE AGE AND SEX CLASSES  
THROUGH THE YEAR*Spring—Adult Male*

*Head Region:* The head color of breeding male Tennessee Warblers has been variously described as ashy-gray, grayish-blue, or pure ash-gray (Eaton, 1914: 393; Ridgway, 1896: 487-8; Roberts, 1936: 684). Dwight (1900: 250), described the first nuptial and adult nuptial plumages as having an ashy-gray cap, white chin, throat, and superciliary line, throat tinged with cream-buff and the trans-ocular streak black. Both Chapman (1907: 83) and Forbush (1929: 223-4) mentioned occasional traces of a chestnut color in the grayish blue or mostly gray crown. Ridgway† stated that there is no rufous or chestnut on the crown in any stage.

Gray feathers on the crown and nape acquired by males in the pre-nuptial molt have a greenish edging. This edging is, in most cases, almost completely worn away by May or June to give the more gray coloration typical of the breeding male bird. Traces of green on the crown and nape in the breeding season are more common than a pure gray color.

The superciliary line is whitish and the stripe through the eye varies from the same shade of gray as on the crown to almost black. The sides of the head below the eye are more white than gray, and the sides of the neck and auricular region are generally gray.

The chestnut coloration mentioned by Chapman and Forbush was observed on thirteen specimens: American Museum of Natural History No.'s 54876, 229856, 56632, 380194, 393162; California Academy of Sciences No. 41025; Carnegie Museum No.'s 102619, 30361; Chicago Natural History Museum No.'s 124992, 207824; Museum of Comparative Zoology No. 189471; National Museum of Canada No. 45707; United States National Museum No. 18325. The chestnut color closely resembles the head color of male Nashville Warblers (*Vermivora ruficapilla*). Measurements of these birds with chestnut in the crown are "typical" for Tennessee Warblers, and specimens exhibiting this color have been collected from widely separated locations on the breeding grounds and outside the area of overlap in the breeding ranges of the Tennessee and Nashville Warblers.

*Remainder of Dorsum:* Forbush and Ridgway were most correct in describing the rest of the upper parts as plain olive-green. The back plumage is worn and dull; the rump is brighter.

*Ventral Surface:* Roberts was incorrect in describing the ventral surface as pure white. Dwight stated that yellow tints of the feathers below were lost by wear. Chapman, Eaton, Forbush, and Ridgway were more correct in describing the ventral surface as dull white or gray-white, often tinged with buffy or yellowish and the sides being greenish or ash-gray. Ridgway stated that the ash-gray is most strong on the sides of the breast.

†Author references in the remainder of this section refer to the work as cited at this point, unless noted differently.

There is considerable variation in the amount of buffiness or gray present on the ventral surface; however, a slight buffy tinge on the throat and upper breast and gray or gray-greenish on the sides of the breast and flanks is most typical. The chin, abdomen, and crissum are a dull white. Adult males that have more yellow or olive-green on the flanks, breast and throat are generally individuals that exhibit more greenish edging on feathers of the head, nape and sides of the neck. These individuals are, however, still distinctly different from the females in coloration.

*Wing:* Forbush and Ridgway described the primaries as being edged with gray. Usually it is just the outer primary (9) or outer two or three (7-9) primaries that are edged with gray on the outer web. The first six (1-6) or more primaries and the secondaries are edged with olive-green on the outer web. The inner webs of all primaries and secondaries are edged with white. Often there is a white tip found in some or all of the first six primaries, but it is rarely present on the outer three primaries.

Chapman stated that the greater and median coverts are narrowly tipped with pale green or greenish-white. This is incorrect. Greater coverts are marked like the secondaries, i.e., edges of the outer webs are green or yellowish-green and edges of the inner webs are white. The green or yellowish-green edging of the greater coverts is wider than the green edging on the secondaries and first six or more primaries. Median and lesser coverts are tipped with an olive-green color and have no white.

*Retrices:* Chapman, Eaton, Forbush and Roberts all noted whitish spots or markings on the inner webs of the outer two tail feathers. These white markings are highly variable, ranging from a thin white edge to a large spot which may cover nearly all the tip of the inner web. In individuals that have only a narrow white edging, the white may be practically non-existent in the spring due to feather wear. Also, the white edging is not restricted to the outer two tail feathers but is generally present on the inner webs of all the tail feathers.

Forbush described the edges of the inner webs of the tail feathers as pale or very pale green. It is the edges of the outer webs that are pale green but not on all of the tail feathers. The outer two tail feathers either do not have a green edging or have only a very indistinct edging. The green edging on the outer webs becomes progressively wider toward the central tail feathers.

#### *Spring—Adult Female*

Descriptions available in the literature are incomplete. Chapman, Eaton, Forbush, Ridgway and Roberts all commented about the same. That is, females resemble adult males, but the crown has more green and the under parts have more yellowish. Ridgway stated that the yellowish color is heaviest on the sides. Chapman reported that the female breeding bird resembles the fall adult male, which is not completely accurate, as will be shown later.

*Head Region:* The crown and nape color is variable from a gray-green to a dull olive-green, but the head color is rarely the distinct

gray of the male. There is a dusky eye-line; the superciliary line is yellow to buffy-white. The sides of the neck have some yellow or olive-green. The sub-orbital region and auricular region are yellow, occasionally mixed with gray.

*Remainder of Dorsum:* The back and rump color is similar to that in the male, i.e., a dull olive-green with the rump color being brighter.

*Ventral Surface:* Usually there is some yellow on the chin, throat, breast, sides of the breast and flanks. The intensity of the yellow is variable. The center of the abdomen is usually white, and the crissum is white.

*Wing and Retrises:* Wings and retrises are marked as in males. The tips of the lesser coverts on some individuals are more yellowish than in males, but this color is variable and cannot be used to distinguish sexes.

### *Summer*

As the season progresses through June and July, adult males become progressively more ragged, deeper gray on the crown, more dull gray-green on the back, more dirty gray-white on the ventral surface. Adult females become more gray-green dorsally and more gray-white ventrally. But the head and ventral surface colors of the two sexes rarely become so much alike that the sexes cannot be distinguished. With the exception of significant variations in the percentage of individuals exhibiting white spots on the inner webs of the outer retrises, no geographic variation in plumage patterns for either males or females collected during June and July on the breeding grounds has been detected (Raveling, 1965).

The postnuptial molt occurs in late July and early August. The molt is complete; both retrises and remiges are replaced, as was stated by Dwight.

A study of the plumages of the young was not undertaken. Immature birds were examined only after the post juvenal molt.

### *Fall—Adult Male*

Adult males in the fall have less gray on the head and more yellow or olive-green on the under parts than spring males, as was stated by Chapman, Eaton and Forbush. The color of the head and under parts is variable. The crown and nape feathers are gray with an olive-green tip. The head color is dependent upon the width of this olive-green tip. The usual head color is dull gray-green, which is distinguishable, in most cases, from the head color of adult females and immatures. Yellow or buffiness on the under parts usually occurs on the breast and throat. As in the spring, adult males that have more green on the head usually have more yellow on the breast and throat and also generally have a more buffy or yellowish superciliary line. Almost all adult males in the fall have yellowish or olive-green tips on the feathers of the sides of the neck.

The wing and tail feathers are marked as in the spring but are much brighter, and the white is more obvious, since feather wear is at a minimum.

The best criterion to use in distinguishing fall adult males from adult females and immatures is the color of the flanks. Adult males have a gray flank, in most instances, or at least an olive-green or very light yellow flank, while adult females and immatures have bright or heavy yellow or olive colored flanks. The gray color on adult males usually extends up and out onto the breast. Goodpasture (1963) ranked fall TV tower killed Tennessee Warblers into four plumage classes based on the amount of green present on the dorsal surface. She concluded that adults could be separated from immatures for the most part, but that the sexes could not be separated based on her method of plumage classification. As noted above, adult males can in fact be identified by plumage, usually just on dorsal head coloration, but most confidently, of course, by considering the entire plumage pattern, especially the flank color. Further, as explained below, and indicated in Goodpasture's (1963) data, many adults are inseparable from immatures on a plumage color basis, and these are the adult females.

#### *Fall—Adult Females and Immatures*

Chapman presented a good description of fall adult females as having no gray on the crown, entire upperparts bright olive-green, underparts white washed with yellow, and resembles the young male in fall but averages less bright above and less yellow below. Chapman described the fall immature female as resembling the adult female but brighter above and with more yellow below and not always distinguishable from the immature male, but averaging more yellow below.

These statements are accurate in describing the general or average situation, but there is considerable variation in the intensity of yellow on the breast, throat and flanks of adult females and immatures (males and females). This variation makes it impossible to distinguish between these three age-sex classes with any confidence.

Forbush stated that immatures are similar to adults in their respective sexes in winter plumage and practically indistinguishable from them. Dwight also mentioned that the young and old become practically indistinguishable. These statements are not completely accurate. As pointed out, the immature male plumage is indistinguishable from the adult female and immature female, but not the adult male plumage.

Immature birds frequently show slightly more wear on the primaries and retrices in the fall than do adults, but this is variable depending upon the time of hatching, molting, etc., and is an unreliable character to use in determining age, as was pointed out by Heydweiler (1936).

#### *Winter*

As winter progresses, feather wear becomes more pronounced. The head color of adult males becomes darker gray but an obvious green tipping is usually still visible. The dull olive-green back and

the buffiness on the breast and throat is lessened due to feather wear. The back color of adult females and immatures becomes dull and the head color slightly gray-green, but not as gray as on adult males. Green tipping of crown feathers is much longer on adult females and immatures than on adult males. This is the reason their head color never becomes as gray as on adult males due to feather wear. The yellow coloration of the ventral surface of adult females and immatures is lessened or becomes more olive-green and dirty.

*Prenuptial Molt:* Dickey and van Rossem (1938) reported that the prenuptial molt begins in late February and is not finished before about the middle of March and involves most of the anterior body plumage but progresses slowly.

The prenuptial molt occurs over a much longer period to time. The earliest date of collection of an individual that exhibited molt was 13 December (Allan R. Phillips No. 6040). There were traces of molt on the crown and chin. The percentages of individuals examined that exhibited some molt are as follows:

Month	Number of Specimens Examined	No. of Specimens Showing Some Molt
December	34	1 (3%)
January	36	18 (50%)
February	51	23 (45%)
March	72	35 (49%)
April	74	22 (30%)

Some birds have completed their prenuptial molt by early February and some have not begun the molt and show the effects of much feather wear. Individuals that have completed their prenuptial molt early may show considerable feather wear by late March and early April before they leave the wintering area. Louisiana State University No. 19584 (male) collected on 29 April in Louisiana, has sheathed feathers on the crown, nape, throat, chin and breast. It is unlikely that this individual spent the winter in Louisiana, and the percentage of individuals that exhibited molt in April suggests that many individuals begin spring migration before completion of the prenuptial molt.

Dwight described the prenuptial molt of first year and older males as a partial one involving chiefly the head, chin and throat and that the molt was less extensive in females. This description is accurate. We have, however, seen a few specimens in which the molt area included the back and far down the flanks, but more commonly it included just the head, nape, chin, throat and upper breast. Females have less yellow in the spring than in the fall.

### *Albinism*

Out of approximately 2000 Tennessee Warblers examined from both museum collections and TV tower kills, we found only one that exhibited partial albinism (Minnesota Museum of Natural History

No. 18125, an adult male killed at the Eau Claire TV tower on 4 September 1961). The outer primary (No. 9) on the left wing and the seventh and ninth primaries of the right wing and the outer three greater primary coverts of each wing are white.

#### MORPHOMETRY OF THE TENNESSEE EARBLER

Tordoff and Mengel (1956) have stressed the importance of having a knowledge of size differences according to sex and age and have criticized workers who have studied individual or geographic variation without regard to sex and age differences. The Tennessee Warbler is a species which exhibits significant variation among the age-sex classes in most mensural characters. The measurements reported in this section are from birds killed in the fall at the Eau Claire TV tower.

Bill length was measured with a divider to the nearest one-tenth of a millimeter from the anterior edge of the nostril to the tip. The tarsus was measured with a divider to the nearest one-tenth of a millimeter from the joint between the tarsometatarsus and tibiotarsus to the joint at the base of the middle toe. Total length was measured to the nearest millimeter from the tip of the bill to the tip of the tail with the specimen stretched as taut as possible. Wing spread was measured to the nearest millimeter from one wing tip to the other with the specimen on its back and stretched as taut as possible. Tail length was measured to the nearest millimeter with a divider from the point of insertion of the central two tail feathers to the tip of the longest tail feather. Wing length was measured to the nearest millimeter on a wing gauge from the carpometacarpus to the tip of the longest primary with the wing pressed flat and straight. Age was determined by the degree of skull ossification; sex was determined by gonadal examination.

Although there is a slight geographic variation in bill length, and apparently in tarsus length also (Raveling, 1965), Table 1 includes the combined samples within an age-sex class to show the variation in these characters for the age-sex classes.

Also presented in Table 1 are the variations in total length, wing spread, tail and wing lengths of Tennessee Warblers in which there are significant variations among the age-sex classes. In all four measurements, immature females are much closer to adult size than are immature males. Immature males not only resemble adult females in coloration but are also close to them in measurements.

#### *Sex Identification from Measurements*

The analysis of any banding data in the future would be much more meaningful and useful if the bander could identify which age-sex class of the Tennessee Warbler he was banding.

*Fall Birds:* Adult males can be distinguished in most instances by plumage, but the recognition of adult females and immatures on a plumage basis would be unreliable. With a combined knowledge of plumage patterns and wing length measurements, it is possible to identify sexes, and also age classes within the male sex, with a high degree of confidence.

TABLE 1. STATISTICAL ANALYSES OF VARIATION IN BILL LENGTH, TARSUS LENGTH, TOTAL LENGTH, WING-SPREAD, TAIL LENGTH AND WING LENGTHS OF FALL MIGRANT TENNESSEE WARBLERS

Character	Statistic*	Adult Male	Immature Male	Adult Female	Immature Female
Bill length	N	196	130	197	161
	$\bar{x}$	7.95	7.91	7.89	7.90
	s	0.33	0.30	0.38	0.30
	$s_{\bar{x}}$	0.02	0.03	0.03	0.02
	R	7.1-9.1	7.0-8.8	7.2-9.0	7.0-8.8
Tarsus length	N	224	124	206	153
	$\bar{x}$	17.18	17.11	16.98	16.95
	s	0.54	0.57	0.54	0.53
	$s_{\bar{x}}$	0.04	0.05	0.04	0.04
	R	15.7-18.6	15.6-18.9	15.3-18.1	15.8-18.6
Total length	N	105	48	119	68
	$\bar{x}$	130.4	127.9	125.9	125.7
	s	2.3	2.3	2.4	2.8
	$s_{\bar{x}}$	0.2	0.3	0.2	0.3
	R	123-135	123-134	120-131	119-132
Wing spread	N	101	44	120	70
	$\bar{x}$	210.5	207.1	201.1	200.2
	s	3.8	4.6	4.2	4.5
	$s_{\bar{x}}$	0.4	0.7	0.4	0.6
	R	199-220	193-217	189-212	188-210
Tail length	N	107	50	129	71
	$\bar{x}$	44.6	43.4	41.9	41.3
	s	1.4	1.5	1.5	1.5
	$s_{\bar{x}}$	0.1	0.2	0.1	0.2
	R	40-47	40-46	38-45	38.45
Wing length	N	109	50	129	73
	$\bar{x}$	66.7	65.5	62.8	62.4
	s	1.4	1.7	1.5	1.4
	$s_{\bar{x}}$	0.1	0.3	0.1	0.2
	R	62-70	59-69	59-66	60-66

\*N = sample size;  $\bar{x}$  = mean; s = standard deviation;  $s_{\bar{x}}$  = standard error of the mean; R = range.

Total length and wing spread measurements of a live bird are not comparable to measurements given in Table 1. Tail measurements alone are not adequate because there is too much overlap. But wing length measurements can be used to identify the sex in Tennessee Warblers. Goodpasture (1963) measured wing lengths (chord) of 113 Tennessee Warblers and showed that all birds of 64 mm. or greater wing length were males and all birds of 61 mm. or

less wing length were females. If one is content to accept only a small amount of error in identifying sex from wing length then one could identify more birds by concluding that all birds of 62 mm. or less wing length were females, and to not attempt sex identification of birds with a 63 mm. wing. We have measured wing lengths flat and straight instead of the chord and our data presented below is thus consistently 1-2 mm. greater than measurements presented by Goodpasture (1963). We feel that measuring the flattened and straight wing is a more consistent and reproducible method and has less error than chord measurements. The major difference between our methods and conclusions as compared to Goodpasture's (1963) is that in addition to being able to identify sex on the basis of wing length, age can be determined within the male sex because of plumage differences. On the basis of wing length alone, the following criteria could be used:

63 mm. or less	female
64 mm.	unknown
65 mm. or above	male

Had this system been used on the animals measured, the following results would have been obtained for the TV tower killed birds:

Age-Sex Class	Total	Correctly Identified	Unknown	Incorrectly Identified	% Accuracy
Adult male	109	106	2	1	99.1
Adult female	129	92	18	19	82.9
Immature male	50	38	8	4	90.5
Immature female	73	55	13	5	91.7
Total	361	291	41	29	90.9

Using 65 mm. or above as male, 64 mm. or less as female, the following results would have been obtained:

Age-Sex Class	Total	Correctly Identified	Incorrectly Identified	% Accuracy
Adult male	109	106	3	97.2
Adult female	129	110	19	85.3
Immature male	50	38	12	76.0
Immature female	73	68	5	93.2
Total	361	322	39	89.2

We believe the former method, that of not attempting to identify individuals with a wing length of 64 mm., is preferable. It may be difficult in measuring the live bird to achieve the straightness of the wing needed to use these figures; therefore, we believe too many males may be identified as females, and as such, birds with a 64 mm. wing should not be identified unless the plumage absolutely signifies an adult male. Also, the bander may be handling mostly immature Tennessee Warblers which would increase the error if the latter method were to be used.

It must be stressed that in order to use the wing length measurements presented here as criteria for sex identification, the wing must be measured as *flat* and *taut* as possible. In addition, the age class within the male sex should never be recorded if there is the slightest doubt as to the plumage color. It takes experience in handling Tennessee Warblers before one can quickly note the plumage differences of adult males.

*Spring Birds:* In the spring, one can identify only the sex since techniques to determine first year breeding birds are not yet available. This can be done by plumage. The figures given for wing length or wing and tail length should not be used on spring birds as feather wear has reduced these measurements. However, for a check on the plumage, one could in most instances be correct in calling birds with wings of 64 mm. or over, males and wings of 63 mm. or less, females.

#### SUMMARY

A description of plumages and plumage changes of the age-sex classes of Tennessee Warblers throughout the year is presented. The descriptions are based on examination of approximately 800 specimens killed during fall migration at a television tower and approximately 1200 museum skins collected throughout the year. Adult male plumage is usually readily distinguishable from female and immature male plumages.

Variation within each age-sex class of bill, tarsus and total length, wing spread, tail and wing length measurements from fall TV tower killed migrants are presented. There are significant differences among the age-sex classes in most of the above characters, with immature females being closer to adult size than immature males. A method of distinguishing between the sexes, and between ages within the male sex, based on wing length measurements and plumage patterns is presented.

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## EXPERIENCES WITH A HELIGOLAND TRAP

By MRS. ROBERT LEACH

I first learned of Heligoland traps through two articles written by J. Woodford and D. J. T. Hussell, published in the July 1961 issue of *Bird-Banding*. Very detailed descriptions of construction and methods of operation were given, along with diagrams and pictures. Soon after, in August of 1961, my family and I began to build a trap along these lines. (These diagrams, taken from the Woodford and Hussell articles, are reprinted for those readers not familiar with the general design of a Heligoland trap. I am indebted to the authors for permission to use the diagrams.) I was influenced in this decision because of having missed one of the best warbler migrations in many springs, due to rain and high winds. Our property is located on a hill and if there is any wind at all, we are apt to get it. Therefore, there are many days, even in good weather, when nets are not usable.